Utilizing Controlled Vibrations in a Microgravity Environment to Understand and Promote Microstructural Homogeneity during Floating-Zone Crystal Growth

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Abstract

It is well established that thermocapillary convection (TC) effectively serves to promote non-uniform solute distribution during float-zone processing that, consequently, degrades crystal properties. Furthermore, the accurate study of TC is compromised by a number of gravity influenced phenomena. In view of the above this work presents, with reference to experiments, our continuing investigation of a processing method that utilizes controlled vibrations that effectively counteract thermocapillary flow.

Previously, our initial experiments identified a novel flow field established by end-wall vibration. The usefulness of the flow field in float-zone processing has been demonstrated in terms of establishing uniform thermal profiles and improved microstructural distributions. The subsequent and overall objective has been to understand the nature of fluid flow, generated by vibration, in a liquid bridge/float-zone through detailed flow visualization and theoretical modeling. Presently, well-designed fluid dynamic experiments are being conducted to extract quality data about the range of the flow field, its parametric dependence, and its effect on thermocapillary flow. To this end, an experimental apparatus has been has been developed to quantify the streaming flow field in silicone oil and water-glycerol bridges.

In addition to experiments, a comprehensive theoretical framework is being developed. An initial study has been completed (Lee, Anilkumar, and Wang, *Phys. Fluids*, 8 (12), 1996). It pointed out that the vibration-driven flow field is a subset of a large family of changeable flow fields set-up due to the non-linear oscillations of liquid bridges; flow fields changing direction and number of loops as the forcing frequency and/or the Reynolds number is changed. This streaming is due to the net body force imposed on the bulk of the column by the vibration. This work is complemented by another recently initiated modeling effort at the Marshall Space Flight Center.

Microprobe comparison analysis (non-vibrated vs. vibrated) of the silver nitrate (dopant) distribution in float-zoned sodium nitrate crystals is continuing. A mechanism for introducing vibration during float-zone crystal growth within the German Ellipsoid Mirror Furnace has been developed; the implications of this are important to any proposed microgravity flight investigation.

Aspects of the above points will be presented with the intent of establishing a background to ensure successful application of the processing technique to a microgravity environment, a combination that will enhance crystal uniformity and our understanding of thermocapillary phenomena. Support from NASA grants NAG8-1230 and NCC8-66 is gratefully acknowledged.